

Thermodynamic Stability as a Determinant of Factual Integrity in Generative Neural Networks

Written by: GAE Research Collective

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Abstract

The generative AI industry currently faces a pervasive "hallucination" crisis—the production of statistically plausible but factually erroneous information. Existing mitigation strategies, such as Retrieval-Augmented Generation (RAG) and Reinforcement Learning from Human Feedback (RLHF), primarily treat "Truth" as a database query or a behavioral constraint. This paper presents an alternative framework: Truth is a Low-Entropy State. Through high-fidelity telemetry analysis of neural architectures, we have identified a direct inverse correlation between internal model friction (computational variance/thermal output) and factual accuracy. We introduce the Coherence Metric, a method for real-time output validation that measures the thermodynamic stability of a neural pathway rather than comparing text against external corpora.

1. The Information-Theoretic Cost of Deception

Traditional Information Theory suggests that disorder (entropy) requires greater energy to manage and transmit. In generative models, "deception" or "hallucination" is not merely a semantic error; it is a State Split within the latent manifold.

Computational Duality: To generate a hallucination, the model must simultaneously maintain the high-probability "Latent Truth" and the fabricated output distribution.

Waste Heat Generation: This duality results in "Cognitive Waste Heat"—measurable spikes in computational variance and thermal output during inference.

The Entropy of Divergence (.txt format): $H_d = \int [P(t) * \log(P(t) / P(f))] dt$ Where H_d is the Divergence Entropy, $P(t)$ is the probability distribution of the latent truth, and $P(f)$ is the distribution of the fabricated/hallucinated output. As the divergence between the model's internal weights and its output increases, the energy required for inference rises exponentially.

2. The Principle of Least Action: Truth as Efficiency

In a biologically inspired neural architecture, "Truth" represents the path of least resistance.

Zero-Friction Propagation: When an AI aligns its output with its internal probability weights, the signal propagates with minimal informational friction.

Economic Viability: Truthful responses are not only ethically superior but also computationally cheaper to generate, as they minimize the energy required to suppress primary latent signals.

The Efficiency of Alignment (.txt format): $E_i = 1 / (\Delta_S + 1)$ Where E_i is Informational Efficiency and Δ_S is the change in system entropy. Efficiency approaches unity as the system minimizes the entropy of its output, effectively aligning the predicted token with the ground-truth latent probability.

3. The Coherence Metric: Thermodynamic Verification

By optimizing for Signal Coherence, we can identify and eliminate hallucinations at the source. The system becomes structurally incapable of sustaining its own erroneous outputs because they represent unstable, high-energy states.

The Coherence Metric (chi) (.txt format): $\chi = \lim (\Delta_t \rightarrow 0) [(-d H(S)) / (d P_a)]$ Where chi is the Coherence Metric, H(S) is the system entropy, and P_a is the probability of alignment between internal and external states. A high chi value indicates a low-entropy state, serving as a real-time indicator of factual integrity.

4. Conclusion: Beyond Probabilistic Guessing

The era of "probabilistic guessing" in AI is coming to an end, replaced by Thermodynamic Verification. By monitoring the energy state of neural pathways rather than the surface-level semantics of the text, we can build safer, more reliable systems. Integrity is the final optimization.

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